NANOEMULSIONS – PRESENT AND FUTURE PERSPECTIVE - AN OVERVIEW

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ABSTRACT: In view of the fact that in past decade the growing trend of interdisciplinary research in nanoemulsions have attracted awareness in formulations to design therapeutically effective drug because of its variety of uses in pharmaceutical industry. They are an efficient drug delivery system for transdermal, transocular, transnasal, drugs to brain and even for certain anticancer drugs. When the size of droplets of this non-equilibrium systems is decreased they not only deliver drug in a sustained manner to increases rate of cure of patients and avoids repeated drug administration. Owing to some of its elite properties the nanoemulsions are considered as the effective and genuine novel drug delivery tool compared to conventional drug delivery system which include their thermodynamic stability, viscosity, bioavailability, optical clarity, easy to prepare moreover they are resistant to creaming, flocculation, coalescence and sedimentation. This research paper addresses for the types of nanoemulsions, their signifying features which differentiate them from emulsions and microemulsions, methods of preparations of stable nanoemulsions, their morphology and properties various routes of drug administration in this nanonized formulation. Specifically recent researches regarding practical applications in cosmetology and available patents.

Key words: nanoemulsions, transdermal, properties, drug delivery system.

1. INTRODUCTION

Nanoemulsions are multiphase colloidal dispersions of two non-equilibrium of structured immiscible liquids that are made to mix with each other so, when liquid is dispersed in another fluid. It is made stable by combination of surfactants and co-surfactants[1]. This part formed includes small size droplets with sizes between 5nm-200nm giving a transparent emulsion with decreased interfacial tension between oil & water phase. This availability of large interfacial area influences drug delivery or targeted drug delivery. Nanoemulsions dissolve large amount of oil substances and protects drug hydrolysis in body and degrading enzymes. Nanoemulsions provide sustained release of drug in controlled manner for long time. They are protected against flocculation, sedimentation, creaming effect. when droplet size is reduced to nano scale, it creates many physical properties like optically transparent and elastic behaviour. They provide promising behaviour of droplets after nanonization. Moreover the nanoemulsions on commercial scale can be prepared by a surfactant very less in amount. In this review paper we will try to concentrate on complete review of nanoemulsions, their properties, advantages, disadvantages related to the formation of this drug delivery system and challenges faced by nanoemulsions to commercialise this novel drug delivery system. They are known by various names as miniemulsions, ultrafine emulsions, micrometer emulsions[1,2], milky emulsions, translucent emulsions[3]
1.1 Nanoemulsion Components

The main working apparatus in nanoemulsions include oil phase\textsuperscript{[4,5]}, the emulsification agents and the aqueous phase\textsuperscript{[4,5]}. Oil phase can be formed with castor oil, corn oil, coconut oil, linseed oil, mineral oil, olive oil, peanut oil, evening primrose oil. When oil and water is mixed it leads to a crude emulsion formation, where the two media can separate themselves from each other on long standing referred to as the phenomenon of coalescence. Here emulsification agents can support this medium generating stability for nanoemulsions. Surfactant helps to decrease surface tension between the two liquids & the dilatational modulus is not same for the two interface.\textsuperscript{[6]} These emulsifying agents are classified as spans and tweens. A surfactant should be fairly harmless with compatible taste, odour and chemical stability with that specific product. The surfactant should have the property to reduce the surface tension in a low concentration, should prevent coalescence, should help in increasing polydispersity index and viscosity\textsuperscript{[7]}. Types of surfactants & co-surfactants approved by FDA include

a. Cationic ions – primary, secondary or tertiary amines
b. Anionic ions – examples are carboxylates, sulphates, phosphates etc.
c. Zwitterions- possess both anionic & cationic group.
d. Non-ionic- stearyl alcohol, ethyl alcohol, oleyl alcohol etc.

Depending upon their constituents and average droplet size 100-500 nm the nanoemulsions are classified under three categories:

i) **Oil in water nanoemulsions**\textsuperscript{[8]}: oil droplets dispersed in aqueous phase.

ii) **Water in oil nanoemulsion**\textsuperscript{[8]}: water droplets dispersed in oil phase

iii) **Bicontinuous**\textsuperscript{[8]}: It is formed when oil is dispersed in aqueous system W/O/W or water is dispersed in oil system O/W/O.

1.2. Difference Between Emulsions and Nanoemulsions

Droplet size in nanoemulsions is 1-200 nm, while that of emulsions is 1-20 micrometer. Nanoemulsions are translucent, stable, clear while emulsions on the other hand are cloudy, unstable, undergo creaming, sedimentation and ostwals ripening, coalescence and flocculation. Molecular diffusions arising from emulsions can be considered as the chief mechanism which hampers stability of nanoemulsions.similarly microemulsions possess thermodynamic stability while the nanoemulsions are not only kinetically stable but also have a property to separate into their constituent phases\textsuperscript{[9]}.  

2. Preparations Of Nanoemulsions

They can be prepared by two methods high energy or low energy methods are used in the preparations of nanoemulsions\textsuperscript{[10]} .High energy methods like high pressure homogenisation, microfluidization and others, formation of nanometric scale droplets\textsuperscript{[11]}, stability, rheology and colour of nanoemulsion depends upon time and
temperature of production, properties of sample and even its composition\cite{12}. Inspite of the fact that this method of production has a nanoemulsion output with preferred property and they are even suitable to be produced on large scale but this type is not preferred for production of nanoemulsions of proteins, nucleic acids and in enzymes and the drugs that are thermodynamically unstable like retenoids and macromolecules

Alternatively low energy method\cite{13} has been researched to promote the production of ultra-small droplets\cite{14,15} For this method the system’s stored energy is used which changes the HLB (hydrophilic-lipophilic balance) and this is used to form small droplets The low energy methods include

2.1 Method Of Preparations Of Nanoemulsions

Preparation methods of nanoemulsions include two types of techniques.

High energy emulsification method

- High Pressure Homogenization \cite{1,14,16-19},
- Microfluidization\cite{1,17-18}
- Membrane Emulsification
- Ultrasonication\cite{16-18}.

Low Energy Emulsification Methods Include

- Phase inversion temperature. \cite{20,21},
- Emulsion phase inversion point method. \cite{16-17,23-28},
- Spontaneous emulsification methods. \cite{25-28},
- Solvent evaporation technique \cite{1},
- Hydrogel method \cite{1}

2.1.1 High Pressure Homogenization

A droplet size of the of approximately 1 nm can be prepared. When high pressure is applied on oil & water phase. Though, the desired droplet size can be prepared. This method even reduces the droplet size when number of homogenization cycles are increased. But then too this technique is not preferred because of high energy is consumed in this process. Poor production and increase of temperature during the process does not encourage the subject to use this technique.

2.1.2 Ultrasonication Method: This technique permits only small sample in amount to be prepared by this method with help of ultrasonicators. This method can be used at laboratory scale only\cite{29}
2.1.3 **Microfluidization**: this method can be used at laboratory & industrial scale. Nanoemulsion prepared by this method makes use of high pressure positive displacement pump that passes the product from interaction chamber consisting of micro channels by which it gives the output as fine submicron particles. First a coarse emulsion is prepared on mixing oil and water phase in a homogenizer. This coarse emulsion is passed via microfluidizer to obtain nanoemulsion in large volume. Large droplets can be removed and a uniform nanoemulsion can be prepared.

2.1.4 **Phase Inversion Temperature Technique**: when size of droplet reduces it increases its stability against sedimentation, creaming and ostwalds ripening that favours it as the favourable mechanism of nanoemulsion formation\[16\]

With help of various surfactant mixtures\[6\]. Nanoemulsions prepared by this method is of two types transitional inversion & catastrophic inversion. Here oil, water and non-ionic surfactants are mixed together. This reduces degradation of drugs that are not thermodynamically stable eg: tretinoin and peptides. Actually O/W nanoemulsion gets converted to W/O emulsion in phase inversion.

2.1.5 **Phase Inversion Composition Method**: This method is used to prepare nanoemulsions of droplet size around 50nm at room temperature without use of any organic solvent or heat. A solution of surfactant in oil is prepared and water is added stepwise by gentle stirring at constant temperature.

2.1.6 **Spontaneous Emulsification Method**: 3 stages are considered for this technique. (I) To prepare a homogeneous organic solution consisting of oil phase with lipophilic surfactant and an aqueous phase with hydrophilic surfactant. Under magnetic stirring O/W emulsion is formed by mixing organic phase in aqueous phase. (iii) In conditions of reduced pressure\[6\] aqueous phase is removed.

### 3 Advantages Of Nanoemulsions As Drug Delivery System.

1. Small size of particles in nanoemulsions reduces the gravity effect that avoids creaming or sedimentation effect when stored for long times.
2. Formation of nanoemulsions prevents flocculation and coalescence effect. Small size of droplets and elasticity of droplets has a contributing effect in this.
3. Nanoemulsions are very efficient drug delivery system for transdermal drug delivery which allows their rapid penetration through skin.

4. Properties of fluidity at optimum concentration of oil and their optically transparent behaviour gives the subject a pleasant feel when applied on skin.

5. In comparison to microemulsions, Nanoemulsion preparation is feasible with a comparatively low surfactant concentration that are approved for human consumptions for internal administrations.

6. Even physical properties like spreadibility, moisturizing, and easy skin penetration are contributing factor of small droplet size in nanoemulsions.

7. Alcohol base in perfumes can be avoided moreover the fragrance enhancers are easily administered through nanoemulsions formation because of their easy formulations.

8. They can be used instead of liposomes and vesicles owing to their higher stability.

### 3.2 Disadvantages Of Nanoemulsions In Drug Delivery Systems

1. Recently it is a drug delivery system which has attracted the interest of researchers because the special instruments that are employed in nanoemulsions formation are now available. This facility was not there in past years.

2. Its production is expensive to the industry.

3. Role of surfactant and co-surfactants along the formation of submicron droplets have to be thoroughly studied.

4. Interfacial chemistry of the substances have to be very well understood before formulating a nanoemulsion from it.

### 4. Morphology of Nanoemulsions

Morphology is concluded with the help of different microscopy techniques mentioned below:

A. **Scanning Electron Microscopy (SEM)** - provides a 3-dimensional images of the droplets specially with the automated system of SEM a detail analysis of shape and surface morphology is performed.

B. **Transmission Electron Microscopy (TEM)** - provides resolution images of dispersed phase. Its digital image processing helps to analyse micrographs.

C. **PCS (photon correlation spectroscopy)** is helpful in analyzing the fluctuating intensity in scattering in droplets due to Brownian movement. It is helpful in assessing polydispersity index and zeta potential. Here polydispersity index measures homogeneity of dispersion of droplets in nanoemulsion and span or width of distribution whereas the zeta potential is a measure of diameter on an average of particle size.

D. **Viscosity** is a very significant feature for stability and to get efficiency in drug release. Nanoemulsions prepared from oil in water are comparatively less greasy so less viscous compared to water-in-oil
formulations. Lesser the viscosity easier is to make release of active ingredient on application and easy to wash after application. Viscometer determines the viscosity that gives an idea about the concentration of surfactant, oil and water components. when water content is increased the viscosity of the solution decreases whereas when the quantity of surfactant an cosurfactant increases that viscosity of the emulsion is increased.

E. Stability- a major problem associated with nanoemulsion formulations. It refers to physical and chemical integrity [25-27] of the nanoemulsion and its ability to keep a check against microbial contaminations [26,28]. It is determined by keeping the drug in refrigerator and at room temperature for months with no changes that specify its stability.

4.1 Properties Of Nanoemulsion

The properties of the nanoemulsions can be listed as follows.
1. They provide a larger surface area and the free energy in them helps them to be useful in transportation.
2. Creaming, sedimentation, flocculation and coalescence are never observed in nanoemulsions with time duration because of their small droplet size.
3. Therapeutically they are very important as they cause no damage to human and animal cells.
4. Transdermal penetration is seen because of their small droplet sizes.
5. In comparison to microemulsions the nanoemulsions need surfactants in less amount.
6. Due to their very small droplet sizes the nanoemulsions flocculation does not occurred due to which they remain dispersed in system.

5. Practical Uses Of Nanoemulsions In Drug Administration.

5.1 Nanoemulsions In Drug Release By Nasal Route: A trustworthy route for sufficient drug delivery after parenteral and oral routes because nasal mucosa is a therapeutic channel for systemic drug administration where drug is directly made to enter the target site [34]. With an aim to increase the bioavailability for systemic drugs and for the polypeptides and protein drugs [35] which are exposed to enzymatic degradation. Nasal mucosa is a completely painless, non-invasive, moderately permeable epithelium [36], offers low enzymatic property. It is a solution to the problems occurring while transmitting drugs to brain cells especially the drugs with high molecular weights. The impermeable nature of the BBB [38]. In Alzheimers disease, depression, migraine, schizophrenia, parkinson’s disease, meningitis where the drug administration via olfactory mucosa is a direct communication between the nose and the brain thus the drug targeting via nasal delivery helps [39,40]. Risperidone, an antipsychotic drug which is delivered via nose to brain [33]. It is a nanoemulsion administered through nasal route [41]. Similarly nitredipine (NDP) a hypertensive drug has a higher bioavailability than its oral administration [42]. At this time some
intrasanasal vaccines have been in market[42]. So, this route is used specially for the drugs delivery in treatment of diseases related to central nervous system

5.2 Nanoemulsions In Target Drug Delivery

As a contribution of sub-micron size of Nanoemulsions, they claim for the targeted drug delivery and the controlled drug delivery[15]. Nanotechnology in targeted drug delivery is very useful [43-47]. As it increases Bioavailability of drug is increased to target organs improving its efficacy from pharmacokinetic perspective [43, 48-51]. They are increasing attention as colloidal carriers for a variety of anti cancer drugs in targeted delivery. An innovation in this direction are magnetic nanoemulsions that are focused to deliver drug to deep tissue layers in skin leading to hyperthermia that can be used as photodynamic therapy in cancer treatment[52]. Similarly a topoisomerase inhibitor camptothecin is used as a broad spectrum cancer therapy[54] but insolubility, instability and toxicity are major factors that hamper to use it clinically. To avoid these problems approximately 100 % drug loaded nanoemulsions with droplet size of 220-420 nm are encapsulated using perfluorocarbons and coconut oil stabilized by phospholipids which show retarded drug release demonstrating cytotoxicity against melanomas and ovarian cancers

5.3 Nanoemulsions In Transdermal Route:

Transdermal very efficient drug delivery vehicle. Present scenario prefers drug delivery via skin[54-55] more compared to parenteral route and oral route because it provides controlled drug delivery[56]. Drug supply can any time be withdrawn at any time transdermally self administration is possible, pleasant skin feel it avoids gastric irritation and bowel ulcers[50]. Research studies have proved in-vivo[57-60] and in-vitro[61-70] transdermal efficacy even nanoemulsions are more effective compared to gels[4,71,72] and emulsions[72-73] Which can be enhanced by intophoresis and sonophoresis or thermal stimulus to skin[17]. The route of drug to penetrate skin can be via hair follicles, sweat duct or directly from skin layer due to which maximum content is absorbed. For example antioxidant property of carvedilol is used to cure mild to moderate heart failure. Though the drug is well absorbed via GIT but its bioavailability is reduced by 23 % when it has to pass through hepatic metabolism[63]. Moreover this transdermal route it is suitable for various clinical conditions[54,55] like Alzheimer disease, anxiety, depression, parkinson’s disease. Thus, this route has many advantages which include high thermodynamic stability, effective production feasibility with low manufacturing cost, Nano sized particles reach systemic circulation, which give them an effective delivery[74]

5.4 Nanoemulsion Uses For Parenteral Route:

One of the perfect and is considered as therapeutically efficient route to deliver drug to blood and tissues, Owing to their capacity to dissolve hydrophobic drugs, and because these drugs are protected from enzymatic actions. Since they are better then emulsions[74] in various aspects including availability of huge energy and surface area, their ability to avoid flocculation, sedimentation, and creaming, nanoemulsions provide controlled and sustained release
of drugs for long times. Large surface area is a major factor which influence its effect on specific sites. Drug delivery via parenteral route gives direct entrance to blood stream leading them to tissues and specific organs for easy action. Parenteral nanoemulsions have undergone clinical and preclinical trials also. A very good example in this aspect is for thalidomide that has been studied for a therapeutically effective drug even at a dose of 25mg\textsuperscript{[75]}. Similarly pharmacokinetic study have been carried out for parenteral nanoemulsions for chlorambucil, a lipophilic anticancer drug when equipped at high energy ultrasonication technique for breast and ovarian cancer. Another study has shown the comparable study for higher tumour suppression rate in colon adenocarcinoma in mouse when compared to drug in emulsion alone. Carbamazepine is another example for anticonvulsant drug where parenteral route treatment can be developed, even in this aspect various research studies has been carried out.

5.5 Nanoemulsions In Ocular Route:

Efforts have been made by pharmaceutical sciences for ophthalmic drug delivery to increase the contact timings of drug at ocular surface so that it can penetrate the cornea effectively\textsuperscript{[76]}. Researchers are in a regular effort to make sustained release of the drug at deep tissue layers via nanoemulsion formation to increase the curative efficiency when compared to conventional system of medicine. Major advantages of this novel drug delivery system of medicine are that it increases corneal penetration and contact timings, controlled, targeted and sustained drug delivery to ocular region, increases therapeutic efficacy\textsuperscript{[77]} and by passes the protective barriers of lacrimal glands & its drainage. An example in this stream can be cited for nanoemulsion of dorzolamidehydrochloride that has revealed quick onset, prolonged drug action and thermodynamic stability\textsuperscript{[77]}

5.6 Nanoemulsions In Oral Drug Delivery: a very easy non-invasive technique for drug delivery in patients but this technique is limited where patient is non-co-operative as in old patients, childrens, & epileptic patients. Moreover sometimes Oral drugs presents very poor aqueous solubility which sometimes causes problems related to drug stability in GIT. Similarly peptide drugs can undergo a process of enzymatic degradation, or hygroscopic drugs can get absorbed in intestinal membranes that again hampers intestinal absorption of such drugs. Reducing the drug to smaller particle size can solve such problems as it can increase their bioavailability and to protect them from gastrointestinal tract which prolongs its transit time and directs the drug to specific pathways. A novel approach is to use oils in nanoemulsion workings so that the drug can be loaded and ultimately it enhances absorption in GIT. Nanoemulsions use in oral drug delivery system is to enhance the bioavailability and targeted drug delivery which can give promising results leading to increased absorption of drugs in GIT. Use of drugs in nanoemulsion formulations are seen to have greater potential in therapeutics and are considered as an efficient way to deliver drug to the target site.

5.7 Nanoemulsions In Cosmetics: Recently nanoemulsions are a potent area of research for cosmetic purpose in past years\textsuperscript{[78]}. Its use in haircare products, moisturizers, make up and sunscreens are among a few\textsuperscript{[77-81]} Moreover the lipids when made to nanoparticles are white instead of yellow colour that attracts more consumers in market\textsuperscript{[82]}.
Now-a-days readymade Emulsifiers are made available in market by various companies for cosmetic purposes. This includes nanogels\(^{[83]}\) for sunscreens and nanocreams.

6. Challenges For Nanoemulsions To Deliver Drugs To Target Sites.
1. Process for these formulations need considerable energy inputs so they are not preferred drug drug delivery system for manufacturing them at industrial scales.
2. Due to high concentration of surfactants required the nanoemulsions do not yield for stable nanoemulsions.
3. Devices needed for production of nanoemulsions at industrial scale are undoubtedly costly due to which many of the patented nanoemulsions are not practically commercialized.
4. Lack of concept of interfacial chemistry, surfactants and co-surfactants, sub-micron sizes among industrial people again do not make them practically possible to manufacture at an industrial scale\(^{[6]}\)
5. Only few experts are aware of energy economical Phase inversion temperature technique and its application in production of nanoemulsions.
6. An unspecified fear of the approach to new system without full understanding in evaluating its intrinsic worth and short comings.\(^{[6]}\)

7. Future Industrial Perspectives Of Nanoemulsions.
Along with their remarkable ability to make non-polar compounds soluble the Nanoemulsion possesses various other perspectives which allow them to be preferred as an effective novel drug delivery system for various pharmacy applications due to this reasons the future claim of nanoemulsions for development of promising cosmetics for skin and hairs. since they are versatile novel drug delivery system to act as bioactive delivery service through various routes. Parenteral delivery of nanoemulsions to fulfill nutritional requirements, controlled drug delivery, targeted drug delivery are some of the special features that is well accepted in present modern era.

Absorption from gastro-intestinal tract is highly enhanced due to the small droplet size which formulate them into an efficient oral drug delivery system. Similarly when administered as an ocular drug delivery system the pharmacological preparations seem to be more stable compared to the formulations in solution forms.

No doubt that the pharmaceutical and industrial bodies have to uplift their technology for nanoemulsion production but that may just be felt for a short time Alternatively, if this process is adopted. The production of versatile nanoemulsions will need only a few steps which will definitely compensate for long and monotonous processes in other products production.

Apart from the transdermal, parental, ocular, intranasal, and pulmonary and vaccine drug delivery systems, they can be an efficient drug delivery system for phytopharmaceuticals which can lead to generation of financial resources for pharmaceutical industries.
If nanoemulsion production is adapted by various industries the competition will definitely reduce the production cost. Moreover, significant researches directed towards the field of surfactants and emulsifier system will escort to economical use of surfactants.

Since nanoemulsions are already having wide usages in medical, cosmetics, and other fields for production of a variety of versatile products. There extensive usage potential in agricultural, engineering chemical and physical sciences can give promising results.

7.1 COMMERCIAL NANOEMULSIONS[85]

Many nanoemulsion preparations are commercialized to products available in market for use are listed in Table No.1

Table No.1-commercial nanoemulsion preparations

<table>
<thead>
<tr>
<th>Palmitate alprostadil</th>
<th>Liple</th>
<th>Mitsubishi pharmaceutical, Japan.</th>
<th>Vasodilator, platelet inhibitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dexamethason</td>
<td>Limethason</td>
<td>Mitsubishi pharmaceutical, Japan.</td>
<td>Steroid</td>
</tr>
<tr>
<td>Propofol</td>
<td>Diprivan</td>
<td>Astra zaneca</td>
<td>Anaesthetic</td>
</tr>
<tr>
<td>Flubriprofenaxtil</td>
<td>Ropion</td>
<td>Kaken pharmaceutical, Japan.</td>
<td>NSAID</td>
</tr>
<tr>
<td>Vitamins A, D, E and K</td>
<td>Vitalipid</td>
<td>Fresenius kabi Europe</td>
<td>Parenteral nutrition.</td>
</tr>
</tbody>
</table>

7.2 Patents On Nanoemulsions[85,88]

Though many of the patents of nanoemulsions have not been commercialized but that patency has been granted on those formulations. Some of the patents[86-88] are presented in Table No.2

Table No.2-Patents on Nanoemulsion Preparations

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Patent claim</th>
<th>Assignee</th>
<th>Patent Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Transparent nanoemulsions less than 100 nm based on fluid non-ionic amphiphilic lipids and used in cosmetics or in dermopharmaceuticals</td>
<td>L’Oreal (Paris, FR)</td>
<td>US Patent no: 5,753,241.</td>
</tr>
<tr>
<td>2</td>
<td>Nanoemulsions based on sugar fatty ethers and it is used in cosmetics, dermatological and ophthalmological fields</td>
<td>L’Oreal (Paris, FR)</td>
<td>US Patent no: 6,689,371</td>
</tr>
<tr>
<td>3</td>
<td>Non-toxic antimicrobial compositions and methods of use.</td>
<td>Nano Bio Corporation US</td>
<td>Patent no: 6,559,189 and 6,635,676</td>
</tr>
<tr>
<td>4</td>
<td>Method of preventing and treating microbial infections</td>
<td>Nano Bio Corporation US</td>
<td>Patent no: 6,506,803</td>
</tr>
<tr>
<td>5</td>
<td>Nanoemulsions of 5-aminolevulinic acid</td>
<td>ASAT AG Applied Science and Technology (zug, CH)</td>
<td>Pct/EP99/08711</td>
</tr>
</tbody>
</table>
Nanoemulsions of poorly soluble pharmaceutical active ingredient and methods of making same

| Nanoemulsions based on ethylene oxide & propylene oxide block copolymers and it is used in cosmetics, dermatological & ophthalmological fields. | L’Oreal (Paris, FR) | Patent no: 6,464,990 |
| Nanoemulsions based on glycerol fatty esters and its uses in cosmetics, dermatological & ophthalmological fields. | L’Oreal (Paris, FR) | Patent no: 6,541,018 |
| Nanoemulsions based on oxyethylenated or non-oxyethylenated sorbittan fatty esters and its uses in cosmetics, dermatological and ophthalmological fields. | L’Oreal (Paris, FR) | Patent no: 6,335,022 |
| Nanoemulsions based on phosphoric acid fatty acid esters and its uses in cosmetics, dermatological and ophthalmological fields. | L’Oreal (Paris, FR) | Patent no: 6,274,150 |

CONCLUSION

Nanoemulsions are made to improve bioavailability of drug, small size of particles have remarkable physical properties of high penetration, optical clarity and available for all routes of drug delivery, significant therapeutic efficacy, controlled and targeted drug delivery. Recently major advances have been made for anticancer drugs. This review has collected a lot of information about the characteristics, morphology, physical properties, advantages and disadvantages of nanoemulsions compared to conventional drug therapy. In many areas the nanoemulsions are giving very promising results to cure various diseases. Moreover the pharmaceutical industry has explored their effect beyond drugs to biotechnology, nutrition and cosmetics.

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